CLAIMS

WE CLAIM:

1. A blood pump comprising:

a housing including a combination of permanent magnets and electromagnets positioned forming an electromagnetic bearing;

an impeller disposed within said housing, said impeller being magnetically suspended with respect to the housing by magnetic flux generated by the combination of permanent magnets and electromagnets, and rotated by an electric motor;

2. A blood pump as defined in claim 1, wherein the magnetic flux from the permanent magnet and the electromagnet shares a common magnetic path.

3. A blood pump as defined in 1, wherein the common magnetic path includes at least part of a soft iron structure within the electromagnet.

4. A blood pump as defined in 1, wherein the common magnetic path includes both radial and axial orientations with respect to an axis of rotation.

5. A blood pump as defined in 1, wherein the impeller is fully suspended along all axes of rotation.

6. A blood pump as defined in claim 1, wherein all blood-contacting surfaces are coated with a wear-resistant biocompatible ceramic coating.

7. A blood pump as defined in claim 6, wherein the ceramic coating is formed of a transition metal nitride.

8. A blood pump as defined in claim 6, wherein the coating is formed of a material selected from the group consisting of titanium nitride, silicon nitride, titanium carbide, tungsten carbide, silicon carbide, and aluminum oxide.

9. A blood pump as defined in claim 6, wherein the ceramic coating is amorphous and conductive.

10. A blood pump as defined in claim 1 which is configured for implantation in a human patient.

11. A blood pump as defined in claim 10, wherein all tissue contacting surfaces are coated with a wear-resistant biocompatible ceramic coating.

12. A blood pump which includes stator and rotor members, wherein the stator defines a common magnetic path for flux generated by both permanent and electromagnet sources, said stator including a first radial component and first axial component attached to the first radial component which collectively define at least a portion of the common magnetic path.

13. A blood pump as defined in claim 12, further comprising a second axial component coupled at a lower end of the first radial component, the combination defining at least a portion of the common magnetic path.

14. A blood pump as defined in claim 12, further comprising a second radial component coupled at a distal end of the first axial component, the combination defining at least a portion of the common magnetic path.

15. A blood pump comprising a combination of housing, stator and rotor members, said rotor being suspended with respect to the stator and within the pump housing by a combination of permanent magnets and electromagnets positioned within the stator, the rotor being suspended by magnetic flux generated by the combination of permanent magnets and electromagnets, and further comprising a controller system connected to said stator, which produces required current for generation of the magnetic flux, said controller system including means for detecting changes in the magnetic flux caused by changes in the position of the rotor, and thereby determining changes in rotor position with respect to the stator without the use of other sensor input.

16. The invention of claim 15 wherein the means for detecting comprises a circuit including a digital sampling system for receiving signals from the pump and deriving the electrical time properties of the coil which indicates the position of the rotor with respect to the stator.

17. The invention of claim 16 wherein the digital sampling system receives signals indicating average current, current envelope, and applied voltage for deriving the electrical time properties of the coil.

18. The invention of claim 15, wherein the controller system receives signals from the means for detecting which indicate the

position of the rotor, said controller system being configured to change the current for generation of the magnetic flux based on said signals so as to reposition the impeller within the housing.

19. The invention of claim 18 wherein the controller system determines the necessary current change parameters by means of a proportional-integral-derivative algorithm.

20. A motor for a blood pump having a pump housing and an impeller magnetically suspended within said housing, said motor comprising: a stator disposed on the inside of the housing and comprising a plurality of non-magnetic core coils radially disposed about the center of the pump, and a rotor comprising an even-numbered plurality of permanent magnets of alternating polarity affixed to the side of the impeller adjacent to the stator, forming a flux gap between the rotor and the stator,. whereby the rotor may be caused to rotate when an alternating current flows through the coils.

21. The motor as described in claim 20, wherein said stator defines a radially curved surface complementary to said rotor, such that said flux gap defines a curved space between the stator and the rotor.

22. The motor as described in claim 21 wherein the flux gap is between about 0.001 inches and 0.100 inches.

23. The motor as described in claim 20, wherein said rotor further comprises a layer of magnetic material affixed to said permanent magnets on the side opposite the stator.

24. The motor as described in claim 20, wherein said stator further comprises a layer of magnetic material disposed between the coils and the housing.

25. The motor as described in claim 20, wherein said rotor further comprises a layer of magnetic material affixed to said permanent magnets on the side opposite the stator, and said stator further comprises a layer of magnetic material disposed between the coils and the housing.

26. The motor as described in any of claims 23-25 wherein said magnetic material is soft iron.

27. An inlet flow passage for a centrifugal blood pump having a flow inlet requiring an acute change in flow direction, said inlet flow passage defining a spiral curve which gradually redirects the flow into the inlet.

28. The inlet flow passage as defined in claim 26 wherein the spiral curve is configured to substantially promote uniform flow and pressure at the inlet.